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THE CRYSTALLINE ROCKS OF THE NORTHWEST.[1]

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I DESIRE to call the attention of Section E to some of the interesting problems that beset the geologist who undertakes to study the crystalline rocks of the Northwest, and especially that part of the Northwest which is included in the State of

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Minnesota. Until very recently it has been the practice of geologists, almost without exception, to refer every crystalline rock in the Northwest either to the Huronian or to the Laurentian. Thus, when the survey of the State of Michigan was reïnaugurated in 1869, the geologists of the upper peninsula were compelled to choose between a confession of their inability to establish the age of the rocks they were studying and the adoption of some of the recognized designations. In Wisconsin the case was similar, with the additional fact that the Michigan geologists were collaborators. The same was true again in Minnesota. What more natural than that the Michigan and Wisconsin rocks should be found to extend, with nearly the same features, into the State of Minnesota, and that their familiar names should at once be applied to them?

But when on more careful examination, both in the field and in the literature of the crystalline rocks, and over a wider extent of territory, and especially in the light of more recent researches in New England, New York, Pennsylvania and Canada, it is found that the nomenclature is imperfect, and furnishes but a tottering scaffold to support the workmen of a great and ever-spreading structure, we are thrown into such difficulty and doubt that we are prone either to reject the old scaffold and build anew, or to clear away the accumulated rubbish about the foundation and examine on what basis the old one stands. To-day, however, we intend to do neither of these, but rather set forth a few of the incongruities and difficulties of the actual situation.

We are indebted, unquestionably, to the geologists of Michigan and Wisconsin for the most exhaustive and satisfactory description of the crystalline rocks of the Archæan age that has yet been published in America. In order that some of the difficulties of the situation may be made clear, I desire to review concisely the broad stratigraphic distinctions of the crystalline rocks that have lately been studied in Michigan, Wisconsin and Minnesota. By the aid of the published results of the surveys of Brooks, Wright, Irving, Rominger, Pumpelly and others, a generalized statement can be formulated. To these I shall add such published results and unpublished field observations from Minnesota as may be furnished by the survey of that State, in order that the scheme may cover correctly the crystalline rocks of the entire Northwest.

Omitting the igneous rocks, which in the form of dikes cut through the shales and sandstones of the Cupriferous formation and are interbedded with them in the form of overflows, we may concisely arrange the crystalline rocks, disregarding minor differences and collating only the broad stratigraphic distinctions, in the following manner in descending order:

There are six groups:

First Group.

Granite and gneiss with gabbro.—This group is represented in Minnesota by the gabbro and red syenite at Duluth, and by the extension of this range of hills north-eastwardly nearly to the international boundary. Its thickness is unknown, but certainly reaches several hundred feet. The outcrop of red granite near New Ulm, lying under the conglomerate and red quartzite, is probably in the south-westward line of extension of this group. This group is represented by No. XX south-west of Lake Michigamme, by No. XX at Menominee and by No. I and Ia at Black river.

Second Group.

Mica schist.—This group consists of schists that are micaceous and often staurolitic as well as garnetiferous. It can be seen in Minnesota on the Mississippi river at Little Falls, and at Pike rapids. The schists are variously associated with beds and veins of granite and gneiss. This is No. XIX at Marquette, XVII to XIX at Menominee, XX to XXII at Penokee, and has a maximum thickness of 5000 feet.

Third Group.

Carbonaceous and arenaceous black slates, and black mica schists.—These sometimes pass into roofing slates, with beds of iron ore, quartzite and diorite. This group includes the black slates of the Animikie group in Northern Minnesota, of Knife lake, and Knife portage on the St. Louis river, and carbonaceous slates lately discovered near Aitkin on the Mississippi river. It includes Nos. XIV to XVII at Marquette, Nos. VI to XVII at Penokee, and Nos. XV and XVI at Menominee. Thickness 2600 feet.

Fourth Group.

Hydro-mica and magnesian schists.—Soft and obscure, becoming quartzose and also hæmatitic, also with numerous beds of

diorite. In Minnesota this is the iron-bearing horizon at Vermilion lake. It is Nos. VI to XIV at Marquette, Nos. IV to VI at Penokee, and Nos. VI to XI at Menominee. Maximum thickness 4450 feet.

Fifth Group.

This is the group of *gray quartzite and marble.* It is represented by No. V at Marquette, Nos. II to V at Menominee and Nos. I to III at Penokee. In Minnesota this horizon seems to run along the south side of Ogishke Muncie lake, near the international boundary, and perhaps includes the great slate-conglomerate which is there represented. Normal thickness from 400 to 1000 feet; but if the great conglomerate of Ogishke Muncie be included here, the thickness of this group in Northern Minnesota will exceed 6000 feet.

Sixth Group.

Granite and syenite with hornblendic schists.—This lowest recognized horizon has frequently been styled Laurentian. In Minnesota it is found on the international boundary at Saganaga lake, and large boulders from it are included in the overlying conglomerate at Ogishke Muncie lake, showing an important break in the stratigraphy. Thickness unknown but very great.

These six great groups compose, so far as can be stated now, the crystalline rocks of the Northwest. Their geographic relations to the non-crystalline rocks, if not their stratigraphic, have been so well ascertained, that it can be stated confidently that they are all older than the Cupriferous series of Lake Superior, and hence do not consist of nor include metamorphosed sediments of Silurian or any later age.[1]

This statement of the grand grouping of the crystalline terranes of the Northwest may be varied by the addition of detailed and minor distinctions and by subdivisions, but its correctness rests upon careful observations and reports of competent geologists and cannot at present be gainsayed.

Examining these groups more closely we find:

I. We have, beneath the red tilted shales and sandstones, a great *granite and gabbro group.* This has been variously regarded by different geologists. While by many early observers it was

[1] The term Silurian here is understood to cover nothing below the base of the Trenton.

classed as older than the series which has latterly been designated Huronian, and by others styled igneous and local, it has, by Brooks, been placed with that series and denominated "the youngest" of the Huronian strata, though no such rocks had ever before been mentioned as pertaining to the Huronian. By Irving it has been made the base of his Kewenawan. By Hunt it has been parallelized with the Montalban. It includes, in my opinion, the felsites and porphyries which have been styled Arvonian, and it is very certain that in many places it has passed for typical Laurentian. The gabbro is very generally admitted to be of eruptive origin, and in its great development in Canada it was once styled Upper Laurentian, and later was known as Norian. While the gabbro is certainly eruptive, the associated granite and gneiss exhibit evidences of being metamorphic in their nature. In Northern Minnesota this horizon of granite is characterized by a red color and it has an aggregate chemical composition almost identical with that of some of the associated felsites. The magnetite of the gabbro is often highly titaniferous and so abundant that the rock has attracted attention as an iron ore. The gabbro does not always appear where the granite is present, but extensive areas of granite are spread out without any sign of variation, interruption or alternation with the gabbro. In other places these two rocks are intricately and intimately mingled both horizontally and perpendicularly; but the gabbro can be considered in general as the underlying formation. Both these rocks seem to have been molten, and simultaneously so, in some places; but in the great mass of the red, granitic rock, there is a gneissic structure, and in its finely crystalline state, when it seems to vary to felsite, it exhibits a laminated structure which is evidently due originally to sedimentation. Along these laminations, and coincident with them, is a finely lined striation which exhibits the "streamed" structure, sometimes appealed to, to show the igneous nature and origin of the rock. These felsites are occasionally arenaceous. with irregularly rounded or sub-angular quartz grains, and sometimes are porphyritic with quartz and orthoclase. Veins of red granite intersect the gabbro, and the gabbro surrounds isolated masses of the granite. Transported, boulder-like masses of both are found embraced in a common paste among the later igneous outflows of the Cupriferous, where their existence is as great a puzzle as that of pebbles of red felsite and quartz-porphyry in the red conglomerates. This red granite, so far as I have observed,

generally consists largely of orthoclase, and in several instances passes imperceptibly into red felsite. It contains also quartz and hornblende, the latter generally changed by decay. The gabbro when unaffected by proximity to the red rock, consists of the three essential ingredients, labradorite, diallage and magnetite, with some necessary products of alteration, but in the vicinity of contact with the red rock it also holds orthoclase and quartz.

II. Below this granite and gabbro group is a series of strata that may be designated by the general term *mica schist group.* This is the principal, but not the only, horizon in which mica schist exists. This division is penetrated by veins and masses of red biotite-granite which appear to be intrusive in somewhat the same manner as the red granite in the gabbro overlying. However, whether this granite is exotic, or can be referred to aqueo-igneous fusion and transmission of the sedimentaries in a plastic state through fissures in the adjacent formations, is a question which still is a matter of earnest investigation. The existence of the great associated igneous gabbro is suggestive, if not demonstrative, of the presence of an adequate agent for such a metamorphism—unless it be claimed, indeed,that such an extravasation of molten rock could take place without any marked and traceable effect on the contiguous formations. These granite veins penetrate only through the overlying gabbro and this underlying mica schist. They are wanting or comparatively rare throughout the rest of the crystalline rocks. On the other hand there is an abundance of diabase and other doleritic rock, in the form of dykes, throughout all the crystalline strata. This points to the mere local nature of the origination of these granitic veins, and hence to the metamorphic nature of the granitic mass with which they are connected. It has been shown by Dana that granite suffers a change to mica schist in Western Massachusetts; Brooks as well as Emmons has shown it interstratified with limestone in St. Lawrence county, New York. They both also state that the Potsdam sandstone becomes gneissic. The same has been affirmed in Vermont by Dr. Hitchcock, and by Dr. Frazer in Pennsylvania. Hence there is no impropriety in supposing that some great change has passed over the sedimentary strata of this horizon throughout a wide extent of country reaching from the Atlantic to Lake Superior, and that in the emergences of upheaval and

dislocation the sediments of one formation were enabled to penetrate transversely into the strata of another.

This mica schist formation has an aggregate thickness of about 5000 feet, and sometimes is hornblendic rather than micaceous.

III. The next lower grand division, which is the third, might be styled the *black mica slate group.* This group contains much carbon, causing it to take the form of graphitic schists, in which the carbon sometimes amounts to over forty per cent.[1] These schists are frequently quartzose, and also ferruginous, even composing valuable ore-deposits, as at the Commonwealth mine in Wisconsin. Associated with these black mica slates, which often appear also as dark clay-slates, are actinolitic schists, the whole being, in some places, interstratified with diorite. Their estimated thickness is 2600 feet.

IV. Underneath this is a very thick series of obscure, *hydromicaceous and greenish magnesian schists*, in which, along with beds of gray quartzite, and clay slates, occur the most important deposits of hæmatitic iron ore. The lower portion of this series, which at Marquette is represented rather by hornblende and chloritic quartz-schists, and more rarely is mined as a magnetic quartz-schist, at Penokee is known as "the magnetic belt." This division of the crystalline rocks has numerous heavy beds of diorite.

V. Below this series of soft schists, which terminate downward with the magnetic iron ores, is the great *quartzite and marble group.* The marble lies above the quartzite, and in the Menominee region has a minimum thickness of at least one thousand feet; while at Marquette it graduates into a dolomitic quartzite of indefinite extent, the whole group there being essentially a quartzite. This is a most persistent and well-marked horizon. The quartzite sometimes holds feldspar, thus having an appearance of granulite. In northern Minnesota, the great slate-conglomerate of Ogishke Muncie lake seems to represent the lower portion of the great quartzite of this group, and to be the equivalent of the lower slate-conglomerate of the "typical Huronian" in Canada. In both places this conglomerate is sometimes speckled with masses of red jasper. The marble of this group appears adjacent to the conglomerate south of Ogishke Muncie lake, and in such

[1] A recent analysis of a specimen from near Aitkin, Minnesota, showed between forty-two and forty-three per cent of carbon.

a position as to overlie it, exposing a thickness of at least twenty-two feet.

Now, the difficulties of the situation arise when we cast about to find names for these parts. What are the eastern representatives of these western groups, and by what designations shall they be known?

Since the geological survey of New York, and the publication of its final report, the progress of geological science in Europe and America has rendered it necessary to revise some of the dogmas which were regarded as fundamental by the New York geologists, and to reject entirely some others. Among these may be mentioned the then current theory that the term "primary" should be applied to any massively crystalline rock, and that all such rocks belong to the bottom of the chronological scale of geology. If the apparent structural relations of the formations, as seen in the field, did not agree with this theory, some violent movement in the earth's crust was at once conjectured so as to bring nature into accordance with the true theory. Latterly, however, it has been shown abundantly by Dana and others, that the Trenton, Hudson River and other Silurian rocks are converted into crystalline schists; by Whitney that the Tertiary rocks become crystalline; by Brooks and Frazer that the Potsdam sandstone becomes gneissic; by Reusch that the clay slates, interbedded with the granites and gneisses of the Bergen peninsula of Norway,[1] contain characteristic upper Silurian fossils, and by Hitchcock that the Helderberg rocks of New York are involved in the crystalline terranes of New-Hampshire.

These more recent crystalline series, however, can all be considered as excluded from the scope of search for any parallels to the crystalline groups of the Northwest. Our inquiry will involve only the well-known names Laurentian, Huronian, Taconic Montalban, Arvonian, Norian.

We meet at the outset with the question which has now become as historic in American geology as the Cambro-Silurian controversy in England, and which concerns very nearly the same geological horizon, viz: Is there a formation such as claimed by Emmons—the Taconic? On this geologists are yet divided. We conceive, however, that the division is caused, not so much by doubt as to the existence of a sedimentary fossiliferous formation

[1] Lesley, Report C4.

below the New York system, and separating it from the "primary," as by doubt as to which and how many of these sub-Silurian strata are to be included in the designation of Taconic. Having now however, given the subject very careful consideration, I am ready to state my very positive conviction that Dr. Emmons was essentially right, and that the Taconic group will have to be recognized by geologists and adopted in the literature of American geology.

Dr. Emmons, in 1842, issued the first that appeared of the volumes of the final report of the New York survey. In that volume he formally sets forth the Taconic system, although, as he admits, in an imperfect manner, the area in which the rocks exist not being in his (the second) district. In this first presentation of the system he extended it geographically too far east, and unfortunately chose a name for it which is appropriate only to a part of that eastward extension. We are indebted to the researches of several volunteer geologists, Wing, Dana, Dale, Dwight, for the disentanglement of the overlying Hudson River rocks from the true Taconic rocks, and the demonstration of the incorrectness of Dr. Emmons' eastward extension of his system in southern Vermont. Dr. Emmons' claim, however, in all its essential points, remains intact. This consists in the existence of a series of sedimentary deposits, largely metamorphic, below the Potsdam sandstone, and separating the Potsdam from the crystalline rocks known as "primary" in an orderly chronological scheme.

In his report on the agriculture of New York, issued four years after that on the geology of the second district, he makes more definite and convincing statements, going over the whole subject *de novo*. He gives diagrams showing the Taconic slates lying below the Calciferous sandrock unconformably, at Whitehall, in Washington county, a region that had been colored by Mather and Hall on their geological maps as Hudson River, and lying in the general area described by Emmons as Tacouic. He gives one also from the hills of Greenbush, opposite Albany, not far from the locality in which Mr. Ford has since discovered primordial fossils, where he also shows the Calciferous lying unconformably upon the Taconic, the former being fossiliferous. He also describes the Hudson River slates as lying unconformably on the Taconic, a fact which cannot be called in question since the recent discoveries of Wing, Dale, and Dwight, and the stratigraphic investigations of Dana. In fact, the investigations of these geologists, in-

stead of destroying the Taconic system, are only confirmatory of the published statements of Dr. Emmons in 1846.

Although the existence of the Taconic in Maine and Rhode Island, as claimed by Dr. Emmons, may not be maintained by further research, it is certain that he had the approval of Dr. Douglas Houghton in extending it into the State of Michigan. In later years, he also traced these rocks through Pennsylvania and Virginia into North Carolina. In Michigan his identifications have since been set aside and the same rocks have been denominated Huronian by Brooks, Wright, Irving and others. In North Carolina Mr. Kerr has, in the same way, substituted the name Huronian. The conclusive fact that these slates had been seen, by Dr. Houghton, in many localities, to pass beneath the Potsdam sandstone, was considered ample to supply the only important point of evidence lacking in the Hudson valley. Dr. Emmons closes his discussion by stating his theme thus, referring to the facts obtained from Dr. Houghton: "It would be difficult to add to the weight of this testimony in regard to the separate and independent existence of a system of fossiliferous rocks, of an age anterior to the Silurian or New York system."

It is not necessary to refer to the controversies that arose from the creation of the imaginary Quebec group, nor to characterize in deserved terms the attempt to bury the Taconic in the Quebec coffin. It is not necessary to quote the support which Emmons had from Barrande, nor to recount the discoveries of Mr. Ford nor the observations of Brooks in St. Lawrence county, N. Y., and Rogers in Pennsylvania, though these last both affirm that beneath the Potsdam sandstone are extensive beds of semi-crystalline strata.[1]

There may be reasons why the current literature of American geology is almost silent respecting the great work of Emmons, and why the Taconic is not known among the recognized geological formations; but we have nothing to do with these at this time. We have now only to say that it seems necessary to admit that when Dr. Emmons insisted on a great group of strata belonging to the age of the Lower Cambrian, lying below the Potsdam sandrock in New York, he had some foundation more substantial than imagination or mere hypothesis. He may have chosen an unfortunate designation. He may have but imper-

[1] Address of H. D. Rogers, 1844, before the Assoc. Amer. Geol. and Nat.

fectly understood the extent and importance of his discovery, and he may have incorrectly described its range and scope, but none of these faults, nor all of them, should deprive him of the credit of having made the discovery. He did more, he defended it to the last day of his life, and averred that "the Taconic system stands out as boldly as the Carboniferous."[1] The argument against the Taconic system which appeals to imperfect or incorrect definition by its author, will apply with equal force against the Silurian system and also against the Cambrian; also against the Huronian and the Laurentian, and perhaps with still greater force against the Hudson River, since none of these were correctly and properly defined at first by their authors.

If the equities of geological nomenclature, in the light of the results of later researches, demand of geologists of this generation a fair consideration of the claims of Dr. Emmons, that consideration must be granted. No amount of error, though heaped to the sky and supported by the highest authority, can long subsist. The truth, though tardy in asserting itself, will finally throw off the burdens under which it labors, and will shine the brighter for the darkness which preceded it.

If we examine the descriptions, given by Dr. Emmons, of his Taconic system, we shall find that he makes the following broad stratigraphic distinctions.

I. His highest member is what he designates *black slate*, which he declares, in some cases, plunges apparently beneath the "ancient gneisses" and contains a considerable amount of carbonaceous matter. In this slate, at Bald mountain, were found two genera of primordial trilobites that were described by Dr. Emmons, the much buffeted *Atops trilineatus*[2] and *Elliptocephala asaphoides*.

II. Under the black slate his next grand distinction was the so-called *Taconic slate*, which he described as argillaceous, siliceous and "talcose," the upper part being suitable for roofing and other portions adapted for flagging. It is greenish, grayish and sometimes of a chocolate color. Its grain is very fine, but in some places it is arenaceous rather than argillaceous. Thickness about 2000 feet.

[1] Letter to Jules Marcou, dated Raleigh, N. C., Nov. 6, 1860.

[2] According to Mr. Ford this is *Conochoryphe*.

III. Below this great mass of soft schists, he described, in the first place, a mass of 500 feet of limestone, designated "Stockbridge limestone," which graduates downward into "talcose" or magnesian sandstones and slates, the whole having a thickness of about 1700 feet.

IV. Under this limestone is his "granular quartz rock," more or less interstratified with slates, and becoming, in some places, an immense conglomerate with a "chloritic paste." In this conglomerate are fragments of the underlying gneiss, or

V. A formation which constituted, in his scheme, the "ancient gneiss" on which the Taconic system was said to lie unconformably.

Now it requires but a glance to perceive how closely this order coincides with that which has been independently and laboriously worked out in the Northwest. We have in both instances a "black slate" which in one case is said to be at the top of the system, but to pass apparently beneath the "ancient gneisses," and in the other is reported to be overlain by a group of mica schist and the "youngest Huronian," a mass of gneiss and gabbro. Below the black slate in both cases is an immense series of soft, hydro-mica and magnesian schists. These again are followed by limestone which in the Northwest often forms marble, and in New England sustains extensive marble quarries. This has various transitions to slate and to a hard sandrock, but in both places it becomes known, in its lower portions, as a great bed of quartzite; and finally at the base is coarsely conglomeritic with masses of rock from the great underlying series of gneiss. Were there no other precedent this very parallelism would at once be taken as demonstrative, or at least indicative, of equivalence of age. The "Stockbridge limestone," however, at Stockbridge, seems to be of the Trenton age, according to Professor Dana; and where it appears in the Taconic mountains, farther south and west, it is assumed by him to be of the same formation. But no one can affirm safely that the Taconic range of mountains is made up of the Trenton and Hudson River formations till the crucial test has been applied to them successfully in the discovery of the characteristic fossils, and assuredly not, in the absence of this test, in the face of the foregoing parallelism with a limestone known to lie much lower; and in the face of the discovery of primordial fossils in Bald mountain some miles fur-

ther north in Washington county, New York. It is to be remembered, also, that the schists of Mt. Washington are distinctly different from those of Southern Vermont containing the Trenton fossils found by Mr. Wing, "a change" taking place in them not far south from the point at which the fossils were found, continuing thence to the southern extremity of Mt. Washington.[1]

We are now, however, confronted with another difficulty. The geologists of Michigan and Wisconsin have set aside Dr. Emmons' identification of the Menominee rocks with the Taconic in 1846, and have called them Huronian, the same that has been done in North Carolina by Mr. Kerr, parallelizing them with the Canadian system, which in 1855 was so named by Dr. T. Sterry Hunt.[2]

It becomes necessary, therefore, to ascertain of what the Huronian consists. Dr. Hunt sets out with the statement that it was designed to include the younger and unconformable series of metamorphic rocks found on the shore of Lake Huron and in the valley of the Thessalon river, "and also the so-called volcanic formations of Lake Superior." Thus the avowed intent was the same as that of Dr. Emmons in erecting the Taconic system. If we seek for the actual stratigraphic and mineralogical characters of these rocks, we shall find them in the geological reports of the Canadian survey, particularly that of 1863.

In descending order the original Huronian consists of the following strata, disregarding the diorites and other "greenstones," all of which are thought by Logan to be of igneous origin, though included in the thickness given.

White quartzite	400 feet.
Limestone	200 "
White quartzite	1500 "
Limestone, siliceous and cherty	400 "
White quartzite	2970 "
Red jasper conglomerate	2150 "
Red quartzite or conglomerate	2300 "
Slate conglomerate	3000 "
Limestone	300 "
Slate conglomerate	1280 "
White quartzite	1000 "
Chloritic and epidotic slates	2000 "
Gray quartzite	500 "
Total	18000 "

[1] Dana *Am. Jour. Sci.* (3), XVII, 376.

[2] Equisse geologique du Canada; Azoic rocks, Rep. E, p. 72.

Of this series of 18,000 feet 900 feet consist of limestone; 2000 feet consist of "chloritic and epidotic slates," and 17,100 feet consist of quartzite and conglomerate. Perhaps 5000 feet of this thickness may be considered intrusive, consisting of diorite and other forms of "greenstone." This will leave 12,000 feet, at least, for the aggregate thickness of quartzite and conglomerate, being nearly double that observed in the same horizon in Northern Minnesota.

It is plain to see that if there be any parallelism between these beds and the various groups made out in the Northwest, the whole of these strata must he made the equivalent of Group v, or the *quartzite and marble group*. The 2000 feet of chloritic and epidotic slates, represented as near the base of the original Huronian, followed as they are by an immense thickness of conglomerate and slate-conglomerate, are anomalous unless there be below them other slate-conglomerates. This, indeed, is very probable, since on the shore of Lake Superior, near the mouth of the River Doré, according to the same authority, the lowest part of the Huronian is seen to consist of a green slaty conglomerate, containing "boulders" of granite and gneiss.

The extension of the term Huronian from the horizon of the original Huronian, upward through the overlying groups, may be justified by the expression of the original intent in the application of the term, but it certainly seems not warranted by any description of rocks by the Canadian geologists, nor by any claim that has usually been put forth by the authors of the name.

There is, therefore, a conflict between the Taconic and the Huronian, both in respect to the horizon which they are intended to cover (both being referred by their authors to the Lower Cambrian) and in the horizon of rocks which they actually compass. The Huronian, however, in its original and typical description, can be parallelized with only the very lowest of the strata that were included in the typical and original Taconic; while the Taconic stretches upward at least as far as to include the fourth and third grand groups made out in the Northwest, that is to say, the *hydro-mica and magnesian schists*, and the *carbonaceous and arenaceous black slates*.

This leaves two series of rocks untouched by the scope of either the Huronian or the Taconic, as these systems were at first defined; namely the *mica schist group*, and the *granite and gneiss*

with gabbro group. In the term *Montalban* proposed for these groups by Dr. Hunt, the two are united and the constant distinctness which they seem to maintain is not recognized. The granite and gabbro group has affinities with the onlying *Cupriferous rocks*, and perhaps, as Irving has suggested, should be considered the base of that series which Brooks has named "Kewenawian," whereas the mica schist group has affinities with the underlying groups, and has, without exception, been assigned to the same system and age as those underlying groups. The granite and gabbro group has likewise been designated differently. The gabbro, being an igneous rock, varies much in its prevalence and in its apparent relation to the granite. Its greatest development produces in Minnesota a range of low hills which extend northeastward from Duluth. Under similar circumstances, this group has received the name *Norian*, though at first called *Labradorian*, and thought to be a part of the Laurentian.[1] The granite and gneiss, also, associated with the gabbro, have received, under one of their modified conditions, the special designation *Arvonian*, on the supposition that these rocks where they so appear, are not modified conditions of granite and gneiss, but represent independent strata that lie near the bottom of the "Huronian" equal in rank to any of the other groups. I think I have shown elsewhere[2] that the Arvonian rocks are interstratified with the Cupriferous, and also that they are modified sediments of the Cupriferous. Instead of being near the bottom of the "Huronian" in the Northwest, they overlie all the groups that have been assigned to the Huronian by Irving, and constitute a part of the great series of "younger gneisses" which by Brooks has been ranked as the "youngest Huronian."

The interesting variety of nomenclature as brought out by the foregoing remarks, can be seen by a glance at the accompanying tabular arrangement, where the various parallelisms and the conflicting nomenclature are placed in adjoining columns.

It is evident from this table that at present it is a hazardous, and perhaps an impossible, undertaking to assign the groups of the crystalline rocks of the Northwest to any of the terranes that have been named further east, without violating somebody's system of nomenclature. Some of the ground has been covered

[1] It was described by Emmons under the term "Hypersthene rock."

[2] A. A. A. S. Cincinnati meeting; Minnesota Survey Rep. for 1880, p. 36; *Ibid.*, 1881, p. 110.

several times by different names, but on different hypotheses of structure, origin, and parallelism. Respecting the horizon known as "Laurentian" there is an approach to unanimity and agreement. This, however, consists more in a tacit consent to style the lowest known rocks Laurentian, than in any agreement among geologists as to the nature and composition of the strata. The Taconic of Emmons, which has been buffeted and combatted from the day of its birth, has from that very circumstance been generally ignored by geologists, because of a certain air of dubious authenticity which accompanies the word. The term Huronian has been allowed to stand and to flourish, partly because of the high authority on which it rests and the remoteness and inaccessibility of the typical locality, and partly, at first because of the non-publication of Dr. Emmons' protestation that it was the equivalent of some part of his Taconic, and later, because, after Emmons' death, as well as before, his opponents were active in spreading views adverse to the Taconic system throughout the literature of American geology. The original Huronian has grown from the dimensions of a single group (the quartzite and marble group), so as to include all the crystalline rocks lying above that group, spreading from the Laurentian to the unchanged sediments of the Upper Cambrian. This has in some cases become so obviously wrong, and has included groups of rocks so plainly extra-Huronian, that a double and triple nomenclature has been applied to a part of these upper rocks, for the purpose of relieving the term of the heterogeneous burden which it was otherwise compelled to carry. These new names, with the exception of the name Montalban, seem to be of value only as regional designations, the strata which they represent being igneous or metamorphic, and hence liable to be wanting in some places and to be non-crystalline in others. They further complicate the stratigraphic nomenclature, since they are probably only the locally modified lower parts of the New York system. Their geographic distribution in the Northwest not only indicates their stratigraphic horizon but also their limited and local existence.

In conclusion, the chief points brought out in this discussion may be stated more concisely:

1. The crystalline rocks of the Northwest are comprised under six well-marked, comprehensive groups.

2. The Taconic of Emmons, so named in 1842, and more correctly defined in 1846, included three of those groups.

3. The Huronian of Canada is the equivalent of the lowest of the Taconic groups, and the perfect parallel of only the lowest of the groups in the Northwest that have been designated Huronian.

4. The uppermost of the groups in the Northwest is local in its existence, and exceptional in its characters, and has received therefore a variety of names.

5. There is, therefore, confusion and conflict of authority in the application of names to the crystalline rocks of the Northwest.

GROUPS.	EMMONS.		HUNT.	BROOKS.	IRVING.	EQUIVALENTS IN MICHIGAN.	EQUIVALENTS IN WISCONSIN.	EQUIVALENTS IN MINNESOTA.
GROUP I. Granite and Syenite with Gabbro.	Hypersthene Rock. (Regarded as part of the Primary.)		Montalban. Labradorian. Norian. Upper Laurentian. Arvonian.	Youngest Huronian.	Base of the Keweenawan.	XX.	I and Ia at Black river.	Duluth. Brulé mountain. Misquah hills. Beaver bay.
GROUP II. Mica Schist.						XIX at Marquette. XVII–XIX at Menominee.	XX–XXII at Penokee.	Little Falls. Pike Rapids. Outlet of Vermilion lake.
GROUP III. Carbonaceous and Arenaceous Black Slate.	Taconic System. 1842–1846.	Black Slate.		The Huronian of Brooks. 1873.	The Huronian of Irving. 1879.	XIV–XVII at Marquette. XV and XVI at Menominee.	VI–XVII at Penokee.	Animikie Black Slates. Grand Portage.
GROUP IV. Hydromica and Magnesian Slate.		Taconic Slate.				VI–XIV at Marquette. VI–XI at Menominee.	IV–VI at Penokee.	At "The Mission," Vermilion lake. Vermilion Iron Mines.
GROUP V. Quartzite and Marble.		Stockbridge Marble. Granular Quartz Rock.	The Huronian of Canada. 1855.			V at Marquette. II–V at Menominee.	I–III at Penokee.	Ogishke-Muncie lake.
GROUP VI. Granite and Gneiss with Hornblendic Gneiss.	Primary.		Laurentian.	Laurentian.	Laurentian.	Laurentian.	Laurentian.	Laurentian.